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Research Article
Evaluation of Waste Ashes for Use in Agricultural Purposes

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Abstract

Background and Objective: There are many suggestions to get rid of the waste ashes by utilizing it in different fields. The agricultural purposes are one of these fields, it may affect the plants, animals and human. So, this study was conducted to observe the characteristics, compositions and the effects of waste ashes on environment before using it in agricultural field. **Materials and Methods:** For this purpose, six samples were taken from old accumulated garbage in Mansoura district, Egypt. Moisture, bulk density, total porosity, pH, EC, total organic C, organic matter, contents of total N, P, K, Mg, Ca and Na, nematodes and grass seeds were tested. The amount of heavy metals in the 6 samples were evaluated. **Results:** Results indicated that all the samples were free from nematodes and grass seeds. Also, the mean values of some nutrients such as; total N, P and K were acceptable. **Conclusion:** The concentrations of heavy metals are very large compared with the permissible values. Therefore, the waste ashes can't be used in the agricultural purposes.

Key words: Waste ashes, incineration process, heavy metals, agricultural purposes, nematodes, grass seeds

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The evaluations of processes that keep and protect the environment alongside energy and resource consumption from the most appropriate to the least appropriate actions are known as a waste management hierarchy. The waste hierarchy is a set of priorities for the efficient use of resources, such avoidance including action to reduce the amount of waste generated by households, industry and all levels of government, resource recovery including reuse, recycling, reprocessing and energy recovery consistent with the most efficient use of the recovered resources and disposal including management of all disposal options in the most environmentally responsible manner[1]. During incineration, N and C nutrients in municipal wastes are eliminated, non-volatile elements are concentrated in altered chemical forms, but P and K are enriched[2-4]. Incineration temperature affects the properties of the resulting ash greatly, dioxin will be generated at low temperatures[5,2], which is a serious environmental problem. Egypt suffers from a big issue related to the waste ashes, where daily wastes are accumulated from populated cities. There are many places in which the waste is accumulated for a long time (maybe 30 years). Due to the self-burning for a long time, the accumulated wastes are transformed into waste ashes. The waste ashes couldn't be recycled or treated. In Egypt, the waste ashes occupy large regions in different important locations. For example, the Sandub region that located in the entrance of EL-Mansoura city, Dakahlia Governorate, Egypt. The volume of the accumulated waste ashes in this location is approximately 32376 m^2 by 30 m high[6]. Application of waste materials to agricultural land presents an opportunity for recovery of essential plant nutrients, many waste products contain concentrations of plant nutrient elements sufficient to produce an agriculturally significant growth response[7]. On other hand, ashes waste usually contains heavy metal based on their initial raw materials[1]. The heavy metals play a significant role in many metabolic processes in plant organisms, but at excessive concentrations, particularly insoluble forms and easily available to plants can cause phytotoxic symptoms. Plant response to high contamination of soil and air with heavy metals is extremely variable and depends on many environmental factors. Besides, according to the study content of the organic substance in soil has a significant impact on the absorption and translocation of heavy metals in soil and their uptake by plants. Cu, Zn, Pb and Cd are adsorbed on organic matter, which generates stable forms and leads to their accumulation in organic horizons of soil and peat[8]. High cadmium concentrations in soils can arise naturally, but more often are due to industrial contamination or through the application of agricultural fertilizers containing high levels of Cd. The possibility of transfer of this contamination to humans through the food chain has led food authorities to set a limit on the amount of Cd allowed in foods for human consumption. A particular concern is a concentration in the tubers of potatoes, which may contribute more than 50% of the dietary intake of Cd[9]. For this reason, current approaches emphasize the need to validate waste ash in terms of the potentially useful or harmful constituents it contains. From this perspective, waste ash management is transformed from a problem of waste disposal to a challenge for resource-utilization without adverse environmental effects[10]. This study examined the possibility of using the waste ashes as fertilizers.

MATERIALS AND METHODS

Study area: The study area, Sandub region, lies in Mansoura district, Dakahlia Governorate, Egypt. It located at 31°05'N latitude, 30°38'E longitude, with an elevation of about 6 m above mean sea level. The samples were taken in 15th October, 2019.

Research procedure: In this study, 6 samples were collected from an accumulated waste ash for assessing it as agricultural fertilizers. Investigated samples were sieved to remove particles with diameter greater than 0.5 mm and air-dried for analysis. The pH and Electrical Conductivity (EC) were determined in a 1/5 (solid/liquid) aqueous extract[11], the organic matter content was determined by calcinations at 750°C for 4 h, total organic carbon was determined by the method of another study[12] . Bulk density was determined by Cylinder method[13] while porosity was estimated according to Hillel[14]. Dry sample (0.5 g) was wet digested by the nitric-perchloric digestion method[15].Total N was determined by using the micro-Kjeldahl method[11]. Total P content was measured by colorimetric[16] and total K and Na were estimated by flame photometry[11]. Secondary nutrients such as; Mg and Ca, trace elements such as; Mn, Mo, B, Cu, Zn, Se, Fe, Mn and the heavy metals such as; 45Sc, 47Ti. 51Cr, 53Cr, 59Co, 60Ni, 88Sr, 111Cd, 118Sn, 137Ba and 208Pb were estimated by using inductively coupled plasma optical emission spectrometer (ICP-OES, Perkin Elmer Optima 2100 DV) after the modified dry-ash method[17].

RESULTS AND DISCUSSION

Physico-chemical characteristics of investigated waste ashes: Data in Fig. 1-7 illustrated some physico-chemical characteristics of investigated waste ashes (i.e., moisture content, bulk density, porosity, pH, EC, organic matter (OM and ashes content).

Moisture content in waste ashes samples was varied from 2-7% (Fig. 1), which may be placed in the low-value range (<30)[18]. Dry organic fertilizer with moisture less than 35% produces high and significant dust amounts. Also, dry organic fertilizer with high OM content is difficult to incorporate into the soil due to it tends to stay on the surface.

Bulk density of the waste ashes samples varied from 1.01-1.17 g cm^{-3} (Fig. 2), while total porosity (%) ranged from 41.67-55.68% (Fig. 3).

The pH of non-metallic fertilizers should be between 6-8[18]. Also, soluble salts can be harmful to plants by producing toxic conditions. Potting soils require a soluble salt content[19] between 2-4 dSm^{-1}. In this study, it was found that pH of the waste ashes samples varied from 7.19-8.83 (Fig. 4), while EC ranged from 4.87-6.86 dSm^{-1} (Fig. 5).

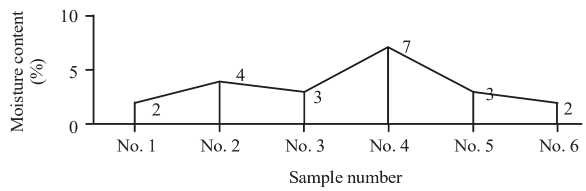

Fig. 1: Moisture content of the 6 samples of waste ashes

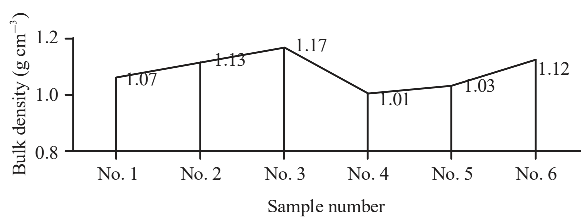

Fig. 2: Bulk density (g cm^{-3}) of the 6 samples of waste ashes

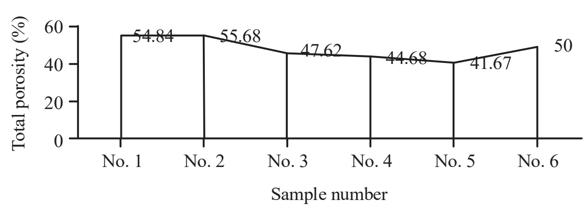

Fig. 3: Total porosity (%) of the 6 samples of waste ashes

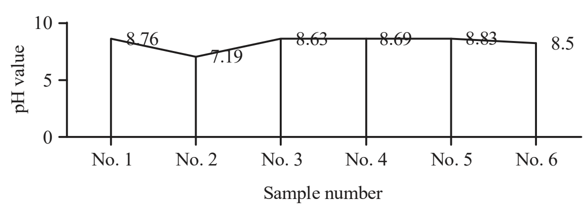

Fig. 4: pH of the 6 samples of waste ashes

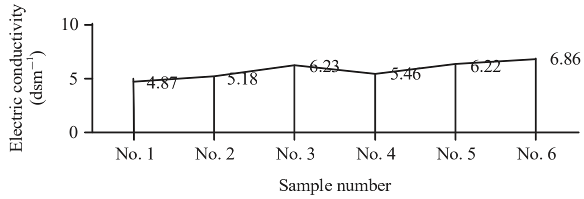

Fig. 5: Electrical Conductivity (EC) (dSm^{-1}) of the 6 samples of waste ashes

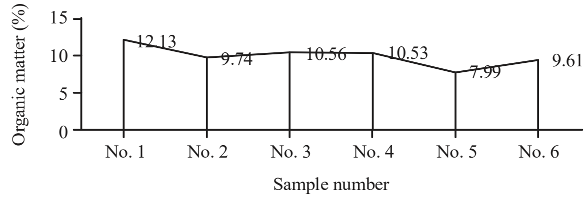

Fig. 6: Organic matter (%) of the 6 samples of waste ashes

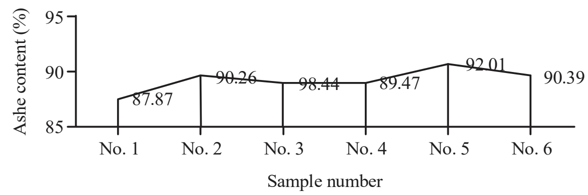

Fig. 7: Ashes content (%) of the 6 samples of waste ashes

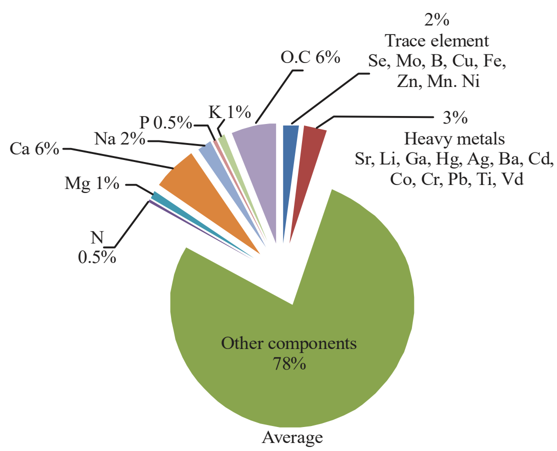

Fig. 8: Elements compositions of waste ashes (average of the 6 samples)

Table 1: Concentrations of heavy metals found in waste ashes (mg kg^{-1}) compared with values with Mohee[20]

Concentrations (mg kg^{-1})		
Heavy metals	Permissible values by Mohee[20]	Mean values of all samples
Hg	0.8	34.00
Cd	3.0	9.36
As	13.0	29.90
Cr	210.0	297.00
Pb	150.0	480.00

The organic matter in waste ashes samples is a necessary parameter for determining the waste ashes application rate, to obtain sustainable agricultural production, it ranged from 7.99-12.13% (Fig. 6). Also, ashes content in all the waste ashes samples ranged between 87.87-92.1% (Fig. 7).

On the other hand, all evaluated samples are free of nematodes and grass seeds. Some physico-chemical characteristics of the evaluated waste ashes may make it suitable for agricultural purposes. However, the element composition of waste ashes will more precisely determine the suitability of ash for agricultural purposes.

Element composition of the waste ashes: The average percentage value of the element composition in the samples is shown in Fig. 8. The element composition of all evaluated samples is similar. The major elements such as; N, P, Na, Mg, K, Ca and trace metals such as; Se, Mo, B, Cu, Fe, Zn, Mn and Ni accounted for approximately 13%, in which micro and trace elements occupied less than 3%. Otherwise, the waste ashes also contain Organic Carbon (OC) (average 6%).

Generally, for the nutrient value of the waste ashes, all samples contained little nitrogen (N) and phosphorus (P), but potassium (K) and calcium (Ca) content in the samples is acceptable. On the other hand, the element Na has a high percentage value in the waste ashes samples, it is known that sodium negatively affects the properties of the soil and the developing plant. The percentage values of heavy metals in the samples were very high as compared with the permissible content according to Mohee[20]. As shown in Table 1, the ratios of heavy metals in the sample were very high compared with permissible values.

The weekly intake of metals should not exceed 0.50 and 0.025 mg kg^{-1} of human body weight for Pb and Cd, respectively[21, 22]. Airborne Pb can be deposited on water, soil and plants, therefore, reaching human's food chain. Pb is accumulated in the skeleton and leads to renal tubular damage and may also give rise to kidney damage. Cd exposure may lead to kidney damage and/or skeletal damage. Heavy metal concentrations of different plant species are directly associated with their concentrations in soils and applied substances to soil. Due to the content of Hg, Cd, As, Cr and Pb in excess of the set norm, the evaluated waste ashes should be excluded from agricultural use. Results of this study were supported by Lam *et al.*[23], who stated that heavy metals such as; Cr, Cd, Cu, Hg and Pb are the most commonly found in ashes. Without proper treatment, these metals may lead to severe and harmful problems to the environment. Also, the authors reported that the concentration of heavy metals in fly ash is higher than in bottom ash because the vaporization of metals during combustion and the metals adsorption process on the surface of fly ash particles.

Generally, waste ashes can't be used as compost because the heavy metals content exceeds the allowable values in compost[24]. Also, accumulated waste ashes in Egypt can be disposed by turning it into red bricks[6].

CONCLUSION

This study displays that all evaluated waste ashes samples contain some macro-nutrients such as; N, P and K within the range of permissible value. Also, the samples are free from nematodes and grass seeds. On the other hand, they contain high concentrations of heavy metals compared with permissible limits, its usage in the agriculture is harmful to soil, plants and human health. Thus, it is impossible to convert the waste ashes into compost or use it in any agriculture purposes.

SIGNIFICANCE STATEMENT

This study discovered that the usage of evaluated waste ashes samples in agriculture is harmful to soil, plants and human health. That can be beneficial for other fields except agriculture proposes. This study will help the researchers to uncover the waste ashes properties that many researchers were not able to explore. Thus, a new theory on the usage of waste ashes may be arrived at.

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